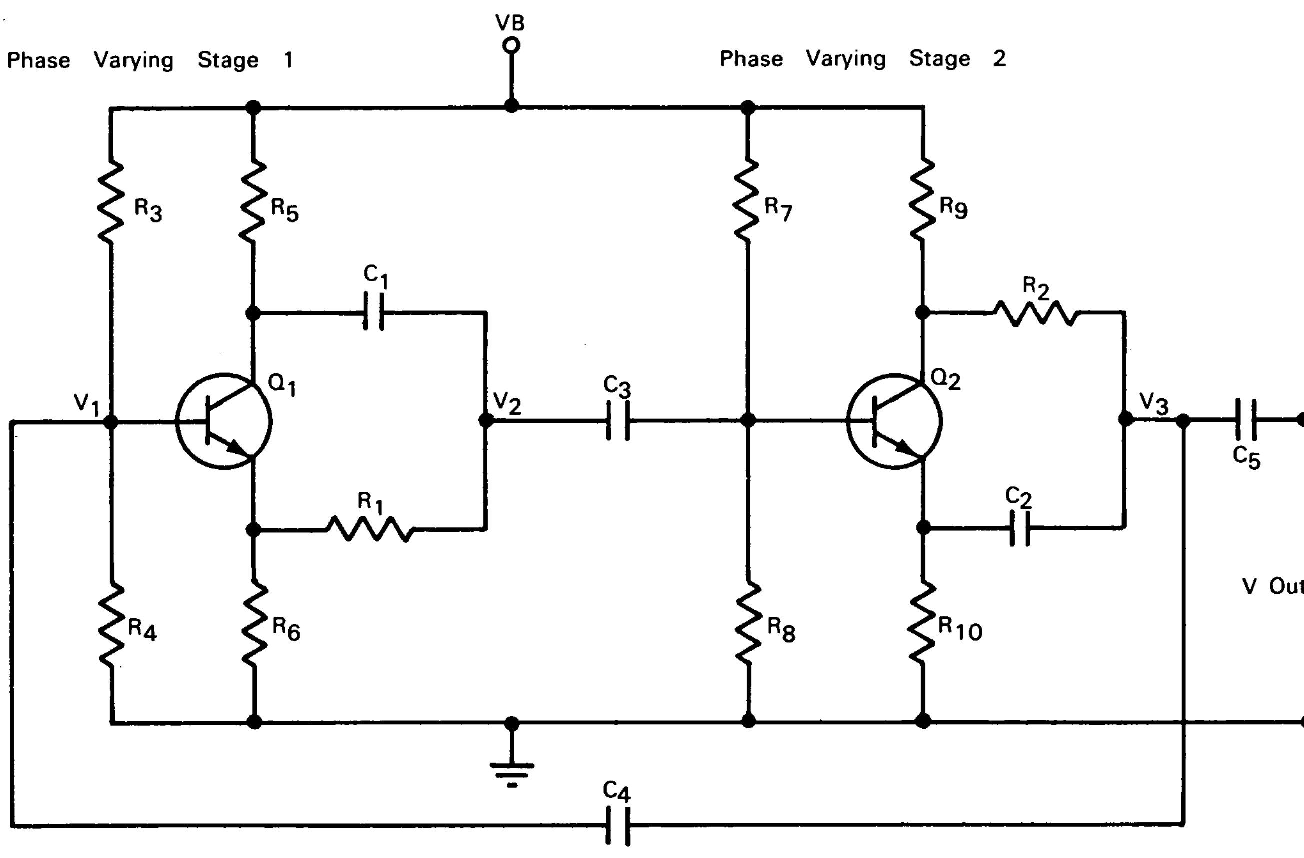
NASA TECH BRIEF

Constant-Amplitude RC Oscillator



The problem:

To design a simple voltage-controlled resistance-capacitance (RC) oscillator to be used in micropower frequency-division telemetry. Nonsinusoidal subcarrier oscillators require low-pass output filters prior to multiplexing. To vary the frequency of an RC Wien-type oscillator without waveform distortion, it is necessary to vary both the control resistors (or capacitors) and to make both elements equal with the closest possible tracking of each other. An automatic gain control arrangement must also be added to insure minimum distortion throughout the tunable frequency range. RC phase-shift oscillators usually have either three resistors or three capacitors which must be ganged to provide a variable frequency operation and still maintain a linear relation between the frequency and resistance (or capacitance).

(continued overleaf)

The solution:

A sinusoidal oscillator is designed with a frequency determined by RC values of two charge control devices and a constant-amplitude voltage independent of frequency and RC values. RC elements can be selected to provide either voltage-control, resistance-control, or capacitance-control of the frequency.

How it's done:

A basic oscillator circuit is designed with two cascaded phase-varying all-pass stages. As shown in the figure, bias resistors R_3, R_4, R_7 and R_8 are chosen in conjunction with load resistors R_5, R_6, R_9 and R_{10} to operate transistors Q_1 and Q_2 with input-to-collector and input-to-emitter voltage gains of unity. Resistor R_1 and capacitor C_1 form an all-pass network. Resistor R_2 and capacitor C_2 form the second all-pass network. The two states are shown ac-coupled by capacitors C_3 and C_4 (dc interconnection is also possible). The transfer function of the first stage, given by:

$$\frac{V_2}{V_1} = 1\angle 2 \tan^{-1} R_1 C_1 \omega$$

demonstrates that variance in the input frequency changes the phase angle but not amplitude of V_2. The first stage provides a positive phase shift from 0 to 180 degrees, depending on frequency and values of R_1 and C_1. The second stage has the same capability but has a phase shift of opposite polarity.

Therefore, if the base-to-collector and the base-to-emitter transistor voltage gains are unity for each stage, and if coupling capacitors C_3 and C_4 have negligible reactance compared to capacitors C_1 and C_2, the circuit will oscillate at a frequency such that the sum of the two phase shifts is equal to zero. The oscillation frequency is

$$f_o = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$

Choosing $R_1 = R_2 = R$, and $C_1 = C_2 = C$, the oscillazation frequency will be $f_o = \frac{1}{2\pi RC}$.

Note:

Additional documentation is available which presents an example of a practical voltage-controlled micropower sub-carrier oscillator and more details of the basic oscillator. This documentation may be obtained from:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: B70-10338

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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